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FALLOUT MIGRATION FROM A SLOPED ROOF

by

Joseph C. Maloney
Andrew S. Miller

February 1970

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B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

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FEBRUARY 1970

FALLOUT MIGRATION FROM A SLOPED ROOF

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Nuclear Effects Laboratory

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A B E R D E E N   P R O V I N G   G R O U N D,   M A R Y L A N D

BALLISTIC RESEARCH LABORATORIES

REPORT NO. 1476

JCMaloney/ASMiller/pc
Aberdeen Proving Ground, Md.
February 1970

FALLOUT MIGRATION FROM A SLOPED ROOF

ABSTRACT

The objective of this overall project was to develop and test radiological countermeasures that are applicable to post-nuclear attack recovery operations.

The specific objective of this phase of the project was to conduct an exploratory experiment on the possible effectiveness of passive roof decontamination, by weather induced migration, in reducing the potential exposure rate in the basement shelter area of a small dwelling having a sloped roof.

For the structure utilized and incident weather encountered:

1. Contrary to expectations that migration would cause dose rates to decrease in basement shelter areas, the actual migration of fallout particles from a sloped roof may cause such dose rates to

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either increase or decrease with time.

2. The presence of gutters can effect a dose increase during early time. The same effect may be expected in some, but not all shelter space if the fallout fell in a line under the roof eaves.

3. Even mild weather conditions can have significant effect on the movement of fallout particles on a sloped roof.

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I. INTRODUCTION

A. Objective

The objective of this overall project was to develop and test radiological countermeasures that are applicable to post-nuclear attack recovery operations.

The specific objective of this phase of the project was to conduct an exploratory experiment on the possible effectiveness of passive roof decontamination, by weather induced migration, in reducing the potential exposure rate in the basement shelter area of a small dwelling having a sloped roof.

B. Background

Previous testing of actual structures and terrain to determine alteration of exposure rates from deposited fallout by incident weather has been very limited. The US Navy conducted ten day migration studies at Camp Parks, Calif. in 1959 and 1960 using a three acre complex of flat roof military barracks, paved surfaces, and lawns[1]*. All horizontal surfaces were contaminated with 150-320μ or 300-600μ silica sand fallout simulant, deposited at $50 g/ft^2$ or $30 g/ft^2$, and tagged with Ba^{140} - La^{140}.

Experimental data indicated that for the 150-320μ fallout:

(1) Wind erosion may reduce the exposure on a large paved area by 30-40%, but obstructions such as curbs, buildings, and vegetation may trap the fallout and cause exposure buildup nearby.

(2) Dry fallout on soil or gravelled flat roofs does not erode appreciably.

* References are listed on page 25.

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For the 300-600μ fallout, the migration effects were less pronounced, although a light rain did cause exposure rate reduction of 10-15% on paved areas.

No data has ever been obtained on the effects of fallout migration in potential dwelling basement shelter areas, or in buildings with sloped roofs.

II. OPERATION

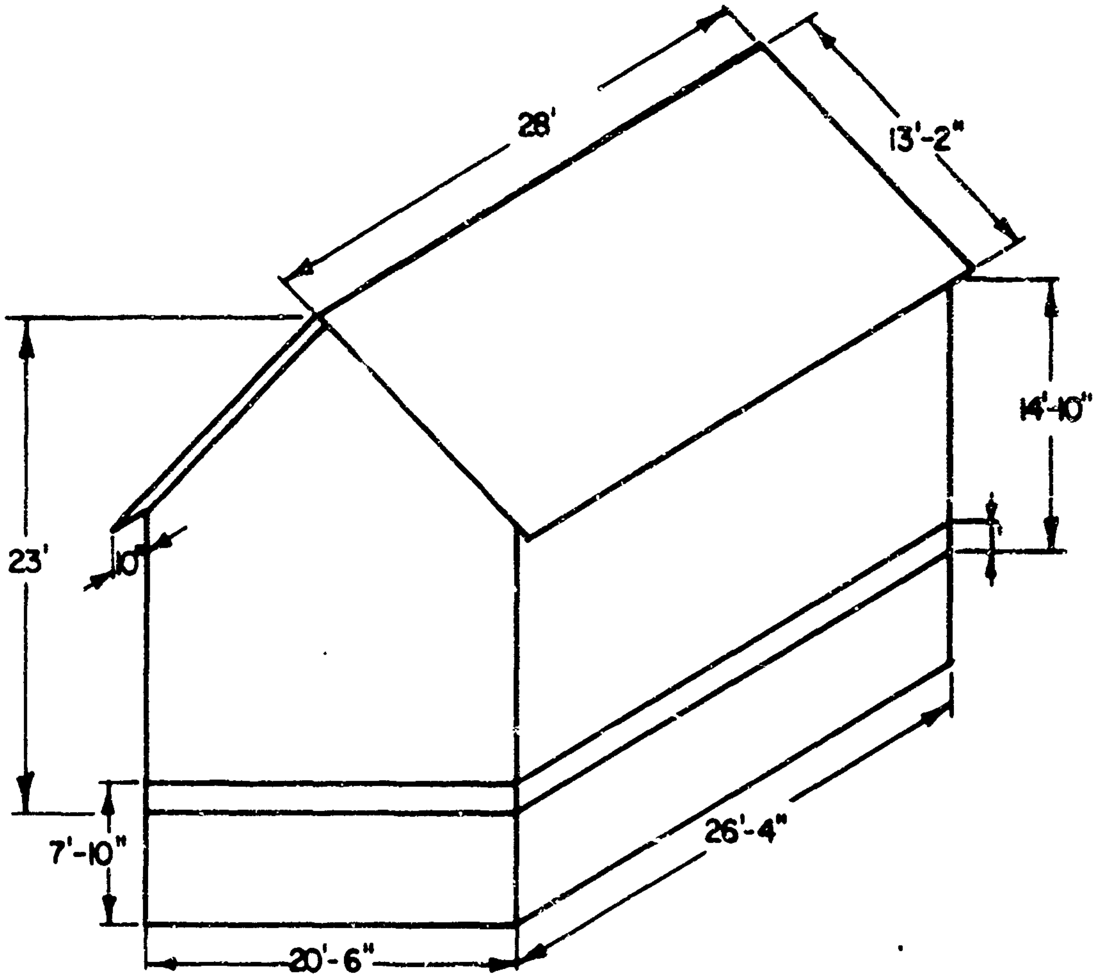
A. Operational Plan

A small four room, two story, former farmhouse of approximate size 20 ft. x 26 ft. x 23 ft. with full basement exists in the Nuclear Effects Laboratory (NEL) nuclear test area of Camp McCoy, Wis. This frame structure has a 1:1 pitch ridged roof surfaced with asphalt shingle roofing. Gutters and downspouting were added at the eaves for this test. Although the structure (Figure 1) was somewhat delapidated (Figure 2), it was, except for broken windows, structurally complete with a sound roof surface.

The following tests were planned and conducted:

(1) Determine exposure rates in the house and basement from fallout deposited and retained on the roof. The roof was covered by an array of plastic tubing (Figures 2 and 3) and a Co^{60} circulating tube source[a] was pumped through the array.

(2) Determine exposure rates in the house and basement from fallout migrating from the roof to the gutters and retained there. The same Co^{60} source was pumped into a short length of plastic tubing which terminated at the end of one gutter. The source was



1. CHIMNEY (NOT SHOWN) 1½ FT. SQUARE RED BRICK.
2. LENGTH: WALL TO WALL INSIDE BASEMENT 24'-6"
3. WIDTH: WALL TO WALL INSIDE BASEMENT 16'-4".
4. STAIRWELL: 2'-8".

Figure 1. Structure Dimensions

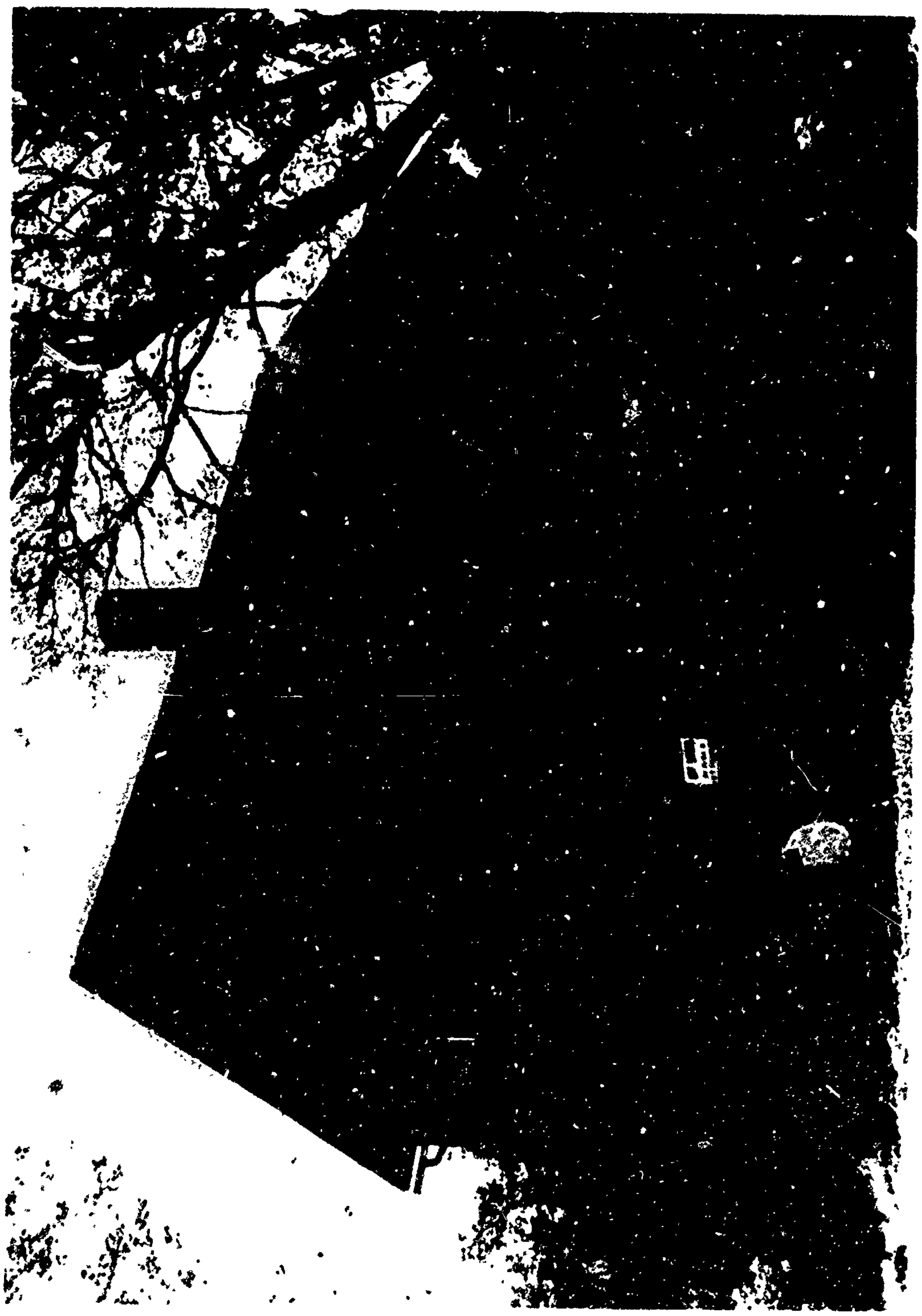


Figure 2. Structure With Source Tubing On Roof

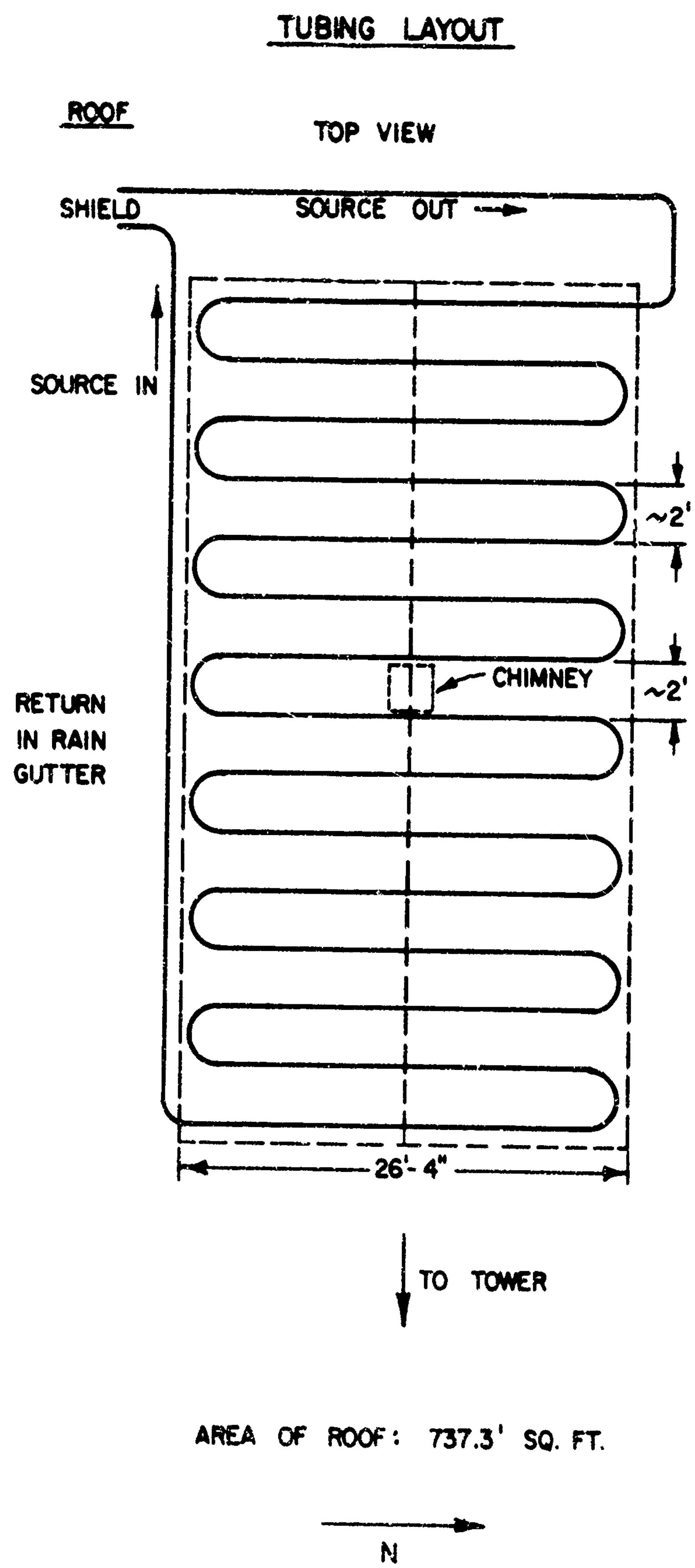


Figure 3. Source Tubing Layout on Roof of Structure

manually pulled along the bottom of the gutter by a mechanical contrivance of cables and pulleys and thus simulated a line source of fallout material in the gutter. The procedure was repeated for the other gutter.

(3) Determine the exposure rates in the house and basement from fallout migration from the roof to a line on the ground under the eaves (condition of no gutters). This was accomplished in the same experimental manner as the gutter line source.

(4) Determine the variation with time in exposure rates in the house and basement due to weather effects on fallout particles deposited on the roof. Simulated fallout particles of 150-300μ silica sand tagged with La^{140} were prepared and deposited at 30g/ft^2 on the roof surface[3]. (Refer to this reference for details of fallout simulant processing and dispersion). Exposure rates at locations of interest were determined at five time intervals during the three days following deposition. At the end of this time, radioactive decay caused exposure rates in the shielded basement area to be so low as to negate the obtaining of meaningful measurements.

B. Instrumentation

Victoreen Model 208 (1mr) and Model 239 (10mr) stray radiation ion chambers[4] were placed in pairs at nineteen locations in the structure (Figure 4) as follows:

1. Three feet above first floor near center of structure (position F). A brick chimney passed through this area and detectors were placed on the side of the chimney which minimized the shielding

DETECTOR PLACEMENT

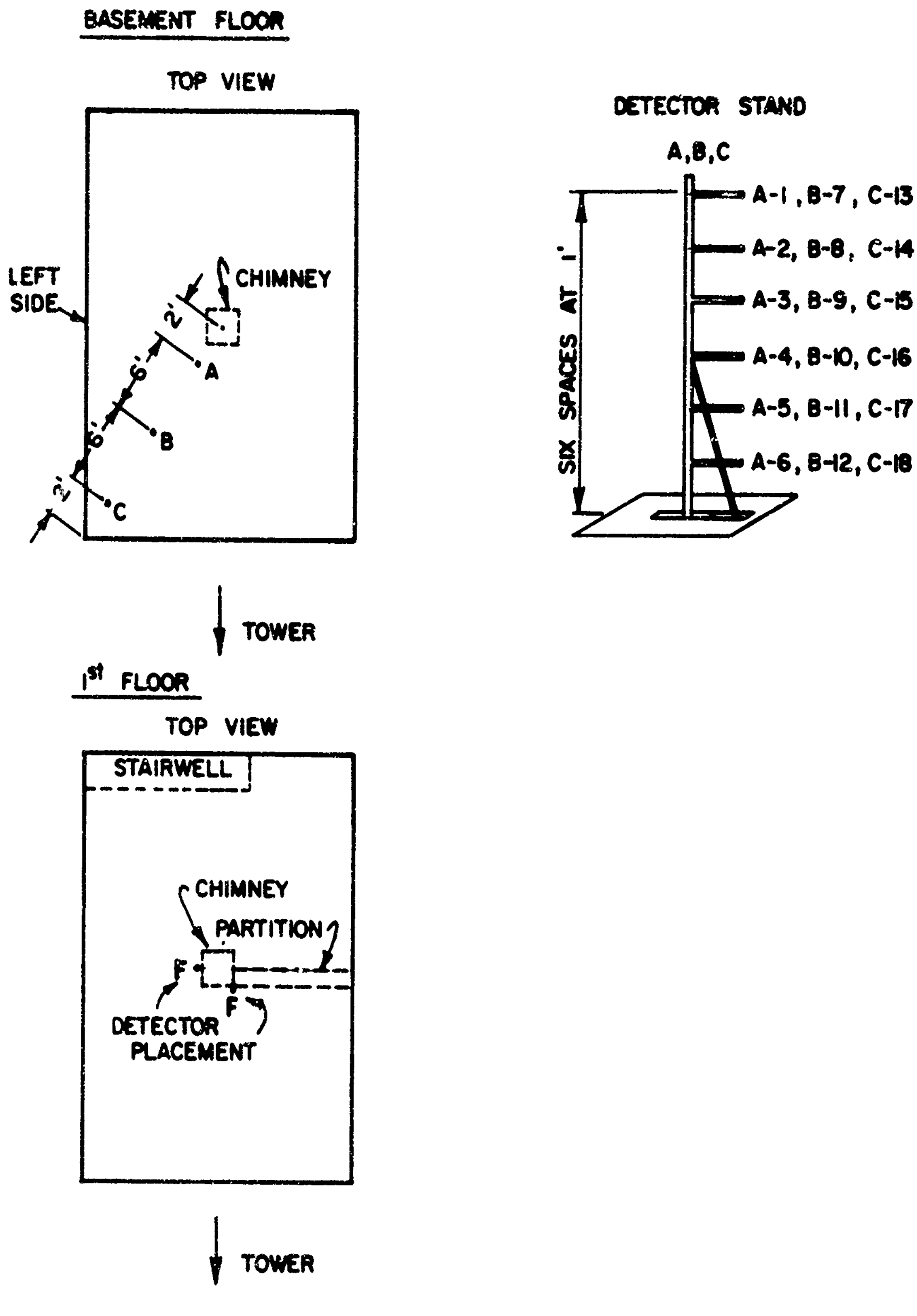


Figure 4. Detector Locations

effect of the chimney on the particular source geometry being used.

2. On a vertical line above the center of the basement at heights of 1,2,3,4,5, and 6 ft. (position A).

3. Similarly on a vertical line at the corner of the basement (position C).

4. Similarly on a vertical line midway between the above (position B).

Readout of Victoreen ion chambers was accomplished utilizing a Model 687 Victoreen Minometer.

C. Data Reduction

The radiation exposures indicated by the ion chambers were corrected to standard temperature and pressure conditions[4] and calibration, exposure time, source strength, and isotopic decay factors were applied in a straightforward arithmetic fortran routine to produce exposure rates in terms of mr/hr/curie of initial roof contamination. It should be noted that each line source in the gutters and on the ground was assumed to contain half of the original roof contamination. (While this assumption is probably not altogether realistic under real weather conditions, it was used for convenient experimentally simulated contamination condition for comparison with results of actual migration.) The individual gutter or ground line source data were added together to give a total gutter or ground line exposure rate.

For the Co^{60} data in which a curie of activity was assumed to be fixed on the roof, in the gutters, or on a line on the ground surface

directly under the eaves, exposure rates were then expressed as ratios of the roof exposure rate as follows:

$$\text{Roof/Roof} = \frac{Rf}{Rf} = 1$$

$$\text{Gutter/Roof} = \frac{Gu}{Rf}$$

$$\text{Ground line/Roof} = \frac{Gl}{Rf}$$

For the La 140 particulate data, all contaminant is assumed to be on the roof at the time of deposition (t_0). Exposure rates measured at later times ($t_1, t_2, \ldots t_i$) are divided by the exposure rate at time t_0 to produce a ratio (D) which can be compared with the above ratios, as simulated by the sources.

III RESULTS AND DISCUSSION

A. Results

Experimental data from Co^{60} simulation of fallout and the ratios of gutter source and ground line source exposure rates to that from the roof are tabulated in Table 1 and illustrated in Figure 5. The exposure ratios as a function of time for La^{140} tagged fallout particles (D) are tabulated in Table 2, and are plotted against time in Figure 5 for visual comparison. Meteorological data for this period of migration are listed in Table 3.

B. Discussion

This experiment considered only the exposure due to fallout originally deposited on the roof of the house. The exposure from ground deposited fallout was not considered since Reference 1 has data to indicate that migration is not significant for that case. Based

Table 1. Co^{60} Source Data and Gutter and Ground Line to Roof Exposure Ratios

Exposure Rate From Source On

Detector Position	Elevation Above Floor Feet	Roof (Rf) mr/h/ci	Gutter (Gu) mr/h/ci	Ground Line (Gl) mr/h/ci	Gu/Rf	Gl/Rf
A-1	6	13.7	20.6	34.5	1.50	2.51
A-2	5	13.7	19.0	32.1	1.39	2.34
A-3	4	12.3	18.2	30.5	1.48	2.48
A-4	3	12.1	18.3	13.7	1.51	1.13
A-5	2	9.84	15.6	8.2	1.58	.832
A-6	1	10.3	14.2	10.0	1.38	.968
B-7	6	16.5	22.7	30.8	1.38	1.87
B-8	5	15.8	21.5	15.4	1.36	.978
B-9	4	14.3	19.4	9.66	1.36	.674
B-10	3	12.9	21.1	9.77	1.64	.759
B-11	2	12.4	17.0	6.52	1.37	.525
B-12	1	10.9	14.7	5.44	1.34	.499
C-13	6	12.7	14.8	52.4	1.17	4.12
C-14	5	11.7	12.6	22.1	1.08	1.89
C-15	4	10.8	14.0	25.4	1.30	2.36
C-16	3	9.69	12.2	28.7	1.26	2.97
C-17	2	9.99	12.6	18.0	1.26	1.80
C-18	1	10.5	11.1	16.2	1.06	1.55
F	3*	30.2	59.1	44.9	1.96	1.49

*3 Feet above first floor

Table 2. Exposure Ratios D From La^{140} Tagged Particles

Detector Position	Elevation Above Floor	to 1500 4 Oct 68	t1 0930 5 Oct 68	t2 1400 5 Oct 68	t3 1130 6 Oct 68	t4 1000 7 Oct 68
	feet					
A-1	6	1.0	1.13	.905	.789	.806
A-2	5	1.0	1.13	.918	.800	.818
A-3	4	1.0	1.10	.836	.756	.769
A-4	3	1.0	1.08	.832	.716	.734
A-5	2	1.0	1.07	.856	.734	.754
A-6	1	1.0	1.02	.825	.719	.722
B-7	6	1.0	1.08	1.04	.797	.829
B-8	5	1.0	1.01	.786	.701	.735
B-9	4	1.0	1.10	.845	.734	.773
B-10	3	1.0	1.14	.869	.749	.786
B-11	2	1.0	1.13	.900	.766	.785
B-12	1	1.0	1.09	.855	.731	.751
C-13	6	1.0	1.21	1.04	.995	1.020
C-14	5	1.0	1.20	.935	.829	.889
C-15	4	1.0	1.14	.815	.771	.794
C-16	3	1.0	1.08	.878	.743	.785
C-17	2	1.0	1.03	.847	.734	.759
C-18	1	1.0	1.12	.943	.791	.796
F	3*	1.0	1.35	1.26	1.06	1.20

*3 Feet above first floor

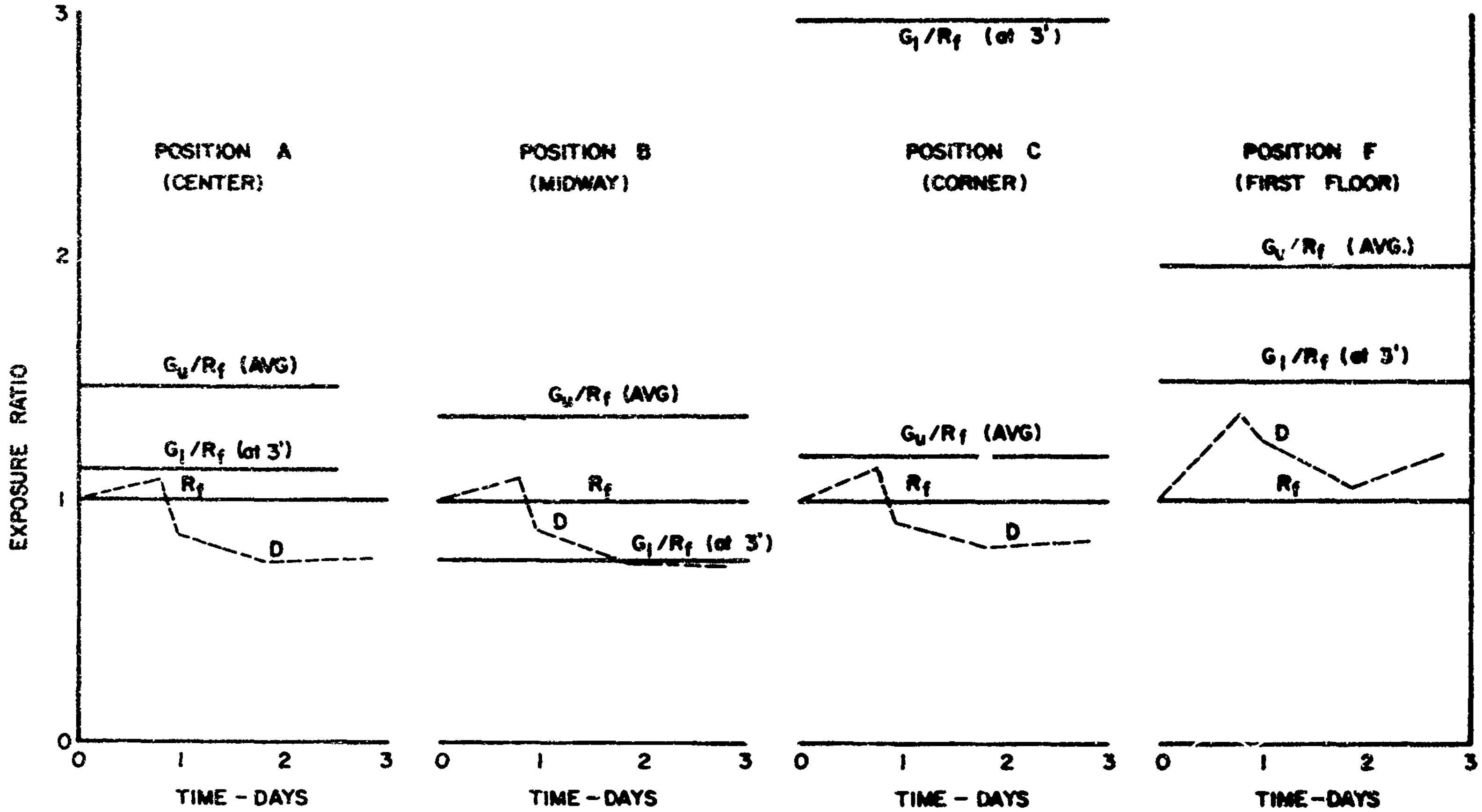


Figure 5. Exposure Ratios of Fallout in Gutters, on Ground Under Roof Eaves, and Under Particle Migration to Fallout on Roof.

Table 3. Meterorological Data

State of Weather Code

0. Clear, less than 1/10 cloud covered
1. Scattered clouds, 1/10 to 5/10 cloud covered
2. Broken clouds, 6/10 to 9/10 cloud covered
3. Overcast, more than 9/10 of sky cloud covered
4. Foggy
5. Drizzly
6. Rainy
7. Snowing or sleating
8. Showering, showers in sight or occuring at station
9. Thunder showers, lightening seen or thunder heard

Date	State of Weather	Dry Bulk	Wet Bulk	Rel Hum	Wind Dir.	Wind Speed	Temp Max	Temp Min.	Amt Precip
		°F	°F	%		MPH	°F	°F	IN.
4 Oct 68	1	51	43	51	W	5	50	26	0
5 Oct 68	3	57	48	51	SW	6	58	25	0
6 Oct 68	3	50	47	87	SW	5	59	41	0
7 Oct 68	1	64	55	56	SE	10	64	30	0

on calculational data presented in a recent publication[5] for a small frame house, the roof deposited fallout would contribute at least half of the dose in basement spaces and therefore migration effects could change about half of the potential dose in the basement shelter areas. For a larger building or one with heavier walls, the roof contribution fraction would be expected to be greater than half, and accordingly migration effects would increase in importance.

The data contained in Table 1 on fixed locations of the fallout source indicate that gutter to roof exposure ratios are relatively insensitive to height above the floor at a given location. However, the ground line to roof exposure ratios vary widely, from half to four times the exposure of the reference roof source location. The migration data in Table 2 show no large variations in exposure on a given detector line, and that the ratios at any time are fairly insensitive to detector line location.

If the roof-deposited fallout were to be moved by weather effects into the gutters, the potential dose in the basement and first floor is always increased. If the fallout were moved to a line source on the ground under the roof eaves, the potential dose is generally, but not always, increased. A limiting case of migration, not experimentally within the resources of the project, would be uniform deposition of the fallout within sixty feet of the house. The authors have made an estimate of the basement area exposure rate for this situation using "in-and-down" experimental data recently acquired by Schmoke[6] of NEL for OCD Subtask 1111. Such exposure rates are about two decades lower

than the roof source exposure case.

Figure 5 illustrates that during the first 18 hours after particulate fallout deposition on the roof, the exposure rates are approximately 10 percent higher than would be expected if there were no migration. Since all detector locations in the basement are about equally affected, it would indicate that the fallout particles migrated to the gutter areas. The postulated migration curve D of this figure does approach the "pure" gutter source case. After 18 hours, the migration curves drop off to about 80 percent of the roof source value, postulating that the particles had been blown off the roof or gutter onto the ground somewhere beyond the pure ground line case and the limiting sixty foot estimate area. Ground surveys with portable radiacs after conclusion of the experiment indicated that all detectable contamination then was limited to the ground in an area extending to eight to ten feet from the house.

Although there was no measurable rainfall or high winds during the first 18 hours of deposition, there was some trace of rain during this overnight period as the roof was wet early in the morning. During the following five hours the roof dried, and apparently the greatest period of migration began under mild wind conditions.

Application of the above migration ratio "D" to the roof contribution of the potential dose (110% during an 18 hour period and 80% from then until two weeks) to standard fallout dose prediction, indicates that the increase and decrease in doses during such a shelter stay time cancel each other. It should be stressed

that this observation is limited to the particular structure tested under the incident weather encountered.

Since the greatest migration effects occurred during the first day, and since this is the period of greatest potential dose during the post nuclear attack period, any future experiments should include many more measurements during this period.

IV. CONCLUSIONS

For the structure utilized and incident weather encountered:

1. Contrary to expectations that migration would cause dose rates to decrease in basement shelter areas, the actual migration of fallout particles from a sloped roof may cause such dose rates either to increase or decrease with time.

2. The presence of gutters can effect a dose increase during early time. The same effect may be expected in some, but not all, shelter space if the fallout fell in a line under the roof eaves.

3. Even mild weather conditions can have significant effect on the movement of fallout particles on a sloped roof.

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6. Private communication with Mr. M. A. Schmoke, 31 March 1969, Nuclear Effects Laboratory, Edgewood Arsenal, Maryland.

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13. ABSTRACT

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FALLOUT SHELTER						
DECONTAMINATION						

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